CLAIMS:

1. A method for generation of sine I and cosine Q branches of a digital phase locked loop comprising the step of processing a digital sampled signal divided into plurality of frames having substantially equal number of samples comprising the steps of:

(a) representing an angular frequency ω^k of the signal for each frame having number k of said plurality of frames as a sum of a nominal angular frequency component ω_0, being a common value to said plurality of frames, and an angular frequency component $\Delta\omega^k$ depending on the frame number k and having an absolute value substantially smaller than a reversed value of a frame size multiplied by a sampling time increment Δt;

(b) calculating for a frame from said plurality of frames data indicative of values of analytical functions including trigonometric functions depending at least on said nominal frequency;

(c) storing the data obtained in step (b);

(d) generating said sine I and cosine Q branches by utilizing the data of the analytical functions stored in step (c), values of the component $\Delta\omega^k$ and the increment Δt for substantially all frames of said plurality of the frames.

2. The method of claim 1 wherein said digital phase locked loop is utilized for amplitude demodulation and envelope extraction.

3. The method of claim 1 wherein step (b) and step (c) are performed off line.

4. The method of claim 1 wherein step (d) is performed on line.

5. The method of claim 1 wherein said analytical functions are arrays of sine and cosine components $a_n^{(s)}$, $a_n^{(c)}$, $b_n^{(s)}$ and $b_n^{(c)}$ calculated according the following equations:

$$a_n^{(s)} \equiv f_n \sin(\omega_0 n\Delta t);$$
$$a_n^{(c)} \equiv f_n \cos(\omega_0 n\Delta t);$$
$$b_n^{(s)} \equiv n\Delta t \cdot a_n^{(s)};$$
$$b_n^{(c)} \equiv n\Delta t \cdot a_n^{(c)},$$

wherein f_n are taps of a low-pass filter; ω_0 is said nominal frequency component; Δt is a sampling time increment; $n = 1,2,\ldots, N$; and N is the number of samples in the frame.

6. The method of claim 1 wherein said analytical functions are arrays of sine and cosine components $\alpha_n^{(s)}$, $\alpha_n^{(c)}$, $\beta_n^{(s)}$ and $\beta_n^{(c)}$ calculated according the following equations:

$$\alpha_n^{(s)} \equiv f_n \sin[\omega_0 (n-p)\Delta t];$$
$$\alpha_n^{(c)} \equiv f_n \cos[\omega_0 (n-p)\Delta t];$$
$$\beta_n^{(s)} \equiv (n-p)\Delta t \alpha_n^{(s)};$$
$$\beta_n^{(c)} \equiv (n-p)\Delta t \alpha_n^{(c)},$$

wherein f_n are taps of a low-pass filter; ω_0 is said nominal frequency component; Δt is a time increment; $n=1,2,..,N/2$; $p=(N+1)/2$; and N is the number of samples in the frame.

7. The method of claim 1 wherein step (b) of calculating the data indicative of values of the analytical functions is performed by utilizing a property of periodicity of the trigonometric functions.

8. The method of claim 1 wherein the step of generating said sine and cosine branches comprising the steps of:

(i) calculating consequently frame by frame for each k-th frame the intermediate quantities σ^k, ξ^k, I_0^k, Q_0^k, I_1^k, Q_1^k, A^k, B^k; and

(ii) calculating the sine I^k and cosine Q^k branches;

wherein $k= 1,2\ldots$; and the calculations are performed according to the following equations:

$$\sigma^k = \sin(\varphi^k);$$

$$\xi^k = \cos(\varphi^k);$$

$$I_0^k = \sum_{n=1}^{N} S_n^k a_n^{(s)};$$

$$Q_0^k = \sum_{n=1}^{N} S_n^k a_n^{(c)};$$

$$I_1^k = \Delta\omega^k \sum_{n=1}^{N} S_n^k b_n^{(c)};$$

$$Q_1^k = \Delta\omega^k \sum_{n=1}^{N} S_n^k b_n^{(s)};$$

$$A^k = I_0^k + I_1^k;$$

$$B^k = Q_0^k - Q_1^k;$$

and

$$I^k = A^k \xi^k + B^k \sigma^k;$$

$$Q^k = -A^k \sigma^k + B^k \xi^k,$$

wherein φ^k is the current phase estimate of the signal; and $\Delta\omega^k$ is said frequency component depending on the frame number.

9. The method of claim 1 wherein the step of generating said sine and cosine branches comprising the steps of:

(i) calculating frame by frame for each k-th frame the intermediate quantities S_n^{+k}, S_n^{-k}, σ^k, ξ^k, I_0^k, Q_0^k, I_1^k, Q_1^k, A^k, B^k; and

(ii) calculating the sine I^k and cosine Q^k branches;

wherein $k = 1, 2 \ldots$; and the calculations are performed according to the following equations:

$$S_n^{+k} = S_n^k + S_{N+1-n}^k;$$

$$S_n^{-k} = S_n^k - S_{N+1-n}^k;$$

$$\sigma^k = \sin(p\omega^k \Delta t + \varphi^k);$$

$$\xi^k = \cos(p\omega^k \Delta t + \varphi^k);$$

$$I_0^k = \sum_{n=1}^{N/2} S_n^{-k} \alpha_n^{(s)};$$

$$Q_0^k = \sum_{n=1}^{N/2} S_n^{+k} \alpha_n^{(c)};$$

$$I_1^k = \Delta\omega^k \sum_{n=1}^{N/2} S_n^{-k} \beta_n^{(c)};$$

$$Q_1^k = \Delta\omega^k \sum_{n=1}^{N/2} S_n^{+k} \beta_n^{(s)};$$

$$A^k = I_0^k + I_1^k \;;$$

$$B^k = Q_0^k - Q_1^k;$$

and

$$I^k = A^k \xi^k + B^k \sigma^k;$$

$$Q^k = -A^k \sigma^k + B^k \xi^k,$$

wherein φ^k is the current phase estimate of the signal; $\Delta\omega^k$ is said frequency component depending on the frame number; and Δt is the sampling time increment.

10. A method for generation of sine I and cosine Q branches of a digital phase locked loop comprising the step of processing a digital sampled signal divided into plurality of frames having substantially equal number of samples comprising the steps of:

(a) calculating and storing a trigonometric component of said sine I and cosine Q branches independent of said frames;

(b) generating said sine and cosine branches using at least (i) mostly multiply and accumulate operation for substantially all of said frames, and (ii) said stored trigonometric component.

11. A digital phase locked loop (PLL) module configured to receive a digital sampled signal divided into plurality of frames having substantially equal number of samples, frequency of the signal for each frame of said plurality of frames is represented as a sum of a nominal frequency component, being a common value to said plurality of frames, and a frequency component depending on the frame number and having an absolute value substantially smaller than a reversed value of a frame size multiplied by the sampling time increment, the PLL module comprising:

(a) at least one Table Memory Unit configured for storing data indicative of values of analytical functions including trigonometric functions depending at least on said nominal frequency;

(b) at least one multiply-and-accumulate unit provided with the data stored in said at least one Table Memory Unit and configured to sum the results of multiplication of said digital sampled signal and said values of analytical functions frame by frame;

(c) at least one Branch Computation Unit receiving the output provided by said at least one multiply-and-accumulate unit and generating sine I and cosine Q branches;

(d) at least one phase detector for generating an error signal for locking the PLL and providing said error signal to said at least one Branch Computation Unit.

12. The PLL module of claim 11 for use in amplitude demodulation, further comprising an envelope computation unit for receiving the sine and cosine branches from said at least one Branch Computation Unit and computing an envelope of said digital sampled signal.

13. The PLL module of claim 12, wherein said at least one phase detector is further synchronized by a synchronization signal delivering phase information of a carrier to the PLL for determination of a sign of the envelope.

14. The PLL module of claim 11 wherein said at least one Table Memory Unit is further coupled to a computing unit for calculating said data indicative of values of analytical functions including trigonometric functions depending at least on said nominal frequency.

15. The PLL module of claim 11 wherein said analytical functions stored in said at least one Table memory Unit are arrays of sine and cosine components $a_n^{(s)}$, $a_n^{(c)}$, $b_n^{(s)}$ and $b_n^{(c)}$ calculated according the following equations:

$$a_n^{(s)} \equiv f_n \sin(\omega_0 n \Delta t);$$

$$a_n^{(c)} \equiv f_n \cos(\omega_0 n \Delta t);$$

$$b_n^{(s)} \equiv n\Delta t \cdot a_n^{(s)};$$

$$b_n^{(c)} \equiv n\Delta t \cdot a_n^{(c)},$$

wherein f_n are taps of a low-pass filter; ω_0 is said nominal frequency component; Δt is the sampling time increment; $n = 1, \ldots, N$; and N is the number of samples in the frame.

16. The PLL module of claim 11 wherein said analytical functions stored in said at least one Table memory Unit are arrays of sine and cosine components $\alpha_n^{(s)}$, $\alpha_n^{(c)}$, $\beta_n^{(s)}$ and $\beta_n^{(c)}$ calculated according the following equations:

$$\alpha_n^{(s)} \equiv f_n \sin[\omega_0 (n-p)\Delta t];$$

$$\alpha_n^{(c)} \equiv f_n \cos[\omega_0 (n-p)\Delta t];$$

$$\beta_n^{(s)} \equiv (n-p)\Delta t \alpha_n^{(s)};$$

$$\beta_n^{(c)} \equiv (n-p)\Delta t \alpha_n^{(c)},$$

wherein f_n are taps of a low-pass filter; ω_0 is said nominal frequency component; Δt is the sampling time increment; $n=1,2,.., N/2$; $p=(N+1)/2$; and N is the number of samples in the frame.

17. The PLL module of claim 11 wherein the summing of the results of multiplication of the sampled digital signal S_n^k and said values of analytical functions by said at least one multiply-and-accumulate unit is performed frame by frame according to the following equation:

$$I_0^k = \sum_{n=1}^{N} S_n^k a_n^{(s)};$$

$$Q_0^k = \sum_{n=1}^{N} S_n^k a_n^{(c)};$$

$$I_1^k / \Delta\omega^k = \sum_{n=1}^{N} S_n^k b_n^{(c)};$$

$$Q_1^k / \Delta\omega^k = \sum_{n=1}^{N} S_n^k b_n^{(s)},$$

thereby obtaining the intermediate quantities I_0^k, Q_0^k, $I_1^k/\Delta\omega^k$, and $Q_1^k/\Delta\omega^k$.

18. The PLL module of claim 11 wherein the summing of the results of multiplication of the sampled digital signal S_n^k and said values of analytical functions by said at least one multiply-and-accumulate unit is performed frame by frame according to the following equation:

$$I_0^k = \sum_{n=1}^{N/2} S_n^{-k} a_n^{(s)};$$

$$Q_0^k = \sum_{n=1}^{N/2} S_n^{+k} a_n^{(c)};$$

$$I_1^k / \Delta\omega^k = \sum_{n=1}^{N/2} S_n^{-k} \beta_n^{(c)};$$

$$Q_1^k / \Delta\omega^k = \sum_{n=1}^{N/2} S_n^{+k} \beta_n^{(s)},$$

wherein

$$S_n^{+k} = S_n^k + S_{N+1-n}^k ;$$

$$S_n^{-k} = S_n^k - S_{N+1-n}^k ,$$

thereby obtaining the intermediate quantities I_0^k, Q_0^k, $I_1^k/\Delta\omega^k$, and $Q_1^k/\Delta\omega^k$.

19. The PLL module of claim 17 wherein said at least one Branch Computation Unit is configured to receive the intermediate quantities I_0^k, Q_0^k, $I_1^k/\Delta\omega^k$, $Q_1^k/\Delta\omega^k$ from said at least one multiply-and-accumulate units and generate the sine I^k and cosine Q^k branches according to the following equation:

$$I^k = A^k\xi^k + B^k\sigma^k ;$$

$$Q^k = -A^k\sigma^k + B^k\xi^k ,$$

wherein

$$\sigma^k = \sin(\varphi^k) ;$$

$$\xi^k = \cos(\varphi^k) ;$$

and

$$A^k = I_0^k + I_1^k ;$$

$$B^k = Q_0^k - Q_1^k ,$$

wherein φ^k is the current phase estimate of the signal.

20. The PLL module of claim 18 wherein said at least one Branch Computation Unit is configured to receive the intermediate quantities I_0^k, Q_0^k, $I_1^k/\Delta\omega^k$, $Q_1^k/\Delta\omega^k$ from said at least one multiply-and-accumulate unit and generate the sine I^k and cosine Q^k branches according to the following equation:

$$I^k = A^k\xi^k + B^k\sigma^k ;$$

$$Q^k = -A^k\sigma^k + B^k\xi^k ,$$

wherein

$$\sigma^k = \sin(p\omega^k\Delta t + \varphi^k) ;$$

$$\xi^k = \cos(\rho\omega^k \Delta t + \varphi^k);$$

and

$$A^k = I_0^k + I_1^k,$$

$$B^k = Q_0^k - Q_1^k,$$

wherein φ^k is the current phase estimate of the signal.

21. In a multi-transmitter environment an array of PLL modules operating on a frame of said plurality of frames in accordance with claim 11, wherein each PLL module of said array is implemented, respectively, for each transmitter of said multi-transmitter environment.

22. The PLL module of claim 11 for use in Cellular Phones and Wireless communication technology.

23. The PLL module of claim 11 for use in MRI and NMR medical systems.

24. The PLL module of claim 11 for use in RF communication components of digital receivers.

25. The PLL module of claim 11 for use in radar systems.

26. The PLL module of claim 11 for use in sonar systems.

27. The PLL module of claim 11 for use in navigation technology and apparatuses.

28. The PLL module of claim 11 for use in car safety systems.

29. The PLL module of claim 11 for use in RF-based systems for antenna positioning.

30. The PLL module of claim 11 for use in industrial applications for motor control.

31. A program storage device readable by machine, tangibly embodying a program of instructions executable by the machine to perform method steps for generation of sine and cosine branches of a digital phase locked loop comprising the step of processing a digital sampled signal divided into plurality of frames having equal number of samples comprising the steps of:

(a) representing an angular frequency ω^k of the signal for each frame having number k of said plurality of frames as a sum of a nominal angular frequency component ω_0, being a common value to said plurality of frames, and an angular frequency component $\Delta\omega^k$ depending on the frame number k and having an absolute value substantially smaller than a reversed value of a frame size multiplied by a sampling time increment Δt;

(b) calculating for a frame from said plurality of frames data indicative of values of analytical functions including trigonometric functions depending at least on said nominal frequency;

(c) storing the data obtained in step (b);

(d) generating said sine I and cosine Q branches by utilizing the data of the analytical functions stored in step (c), values of the component $\Delta\omega^k$ and the increment Δt for substantially all frames of said plurality of the frames.

32. A computer program product comprising a computer useable medium having computer readable program code embodied therein for generation of sine

and cosine branches of a digital phase locked loop the computer program product comprising:

computer readable program code for causing the computer to represent an angular frequency ω^k of the signal for each frame having number k of said plurality of frames as a sum of a nominal angular frequency component ω_0, being a common value to said plurality of frames, and an angular frequency component $\Delta\omega^k$ depending on the frame number k and having an absolute value substantially smaller than a reversed value of a frame size multiplied by a sampling time increment Δt;

computer readable program code for causing the computer to calculate for a frame from said plurality of frames data indicative of values of analytical functions including trigonometric functions depending at least on said nominal frequency;

computer readable program code for causing the computer to store the data indicative of values of analytical functions including trigonometric functions depending at least on said nominal frequency;

computer readable program code for causing the computer to generate said sine I and cosine Q branches by utilizing the stored data of the analytical functions, values of the component $\Delta\omega^k$ and the increment Δt for substantially all frames of said plurality of the frames.